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Clinical Study

Spinal tumors in children: long-term retrospective evaluation of a series of 134 cases treated in a single unit of pediatric neurosurgery

Barbara Spacca, MD, Flavio Giordano, MD, Pierarturo Donati, MD, Lorenzo Genitori, MD*

Department of Neuroscience, Unit of Pediatric Neurosurgery, "Anna Meyer" Children's Hospital, Viale Pieraccini, 24, 50139 Florence, Italy

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Abstract

BACKGROUND CONTEXT: Spinal tumors in childhood are rare and heterogeneous, and their treatment is very demanding. It is necessary to both manage the disease and preserve the spinal stability so that the spine can grow normally. As a consequence, results in terms of both mortality and morbidity are often suboptimal.

PURPOSE: The results of a single pediatric neurosurgery institution are reported to highlight the peculiarities and pitfalls of the management of this disease. Tumors are analyzed from the point of view of their localization, histology, and outcome in terms of mortality and morbidity, with a special focus on postoperative spinal deformity.

STUDY DESIGN: The study design was retrospective.

PATIENT SAMPLE: Between 1995 and 2011, 134 children (75 males and 59 females) were admitted for spinal tumors, accounting for 7.7% of all the patients admitted for central nervous system malignancies. The mean age was 8.5 years (14 days–26 years), and the mean follow-up was 28 months (3 months–13 years).

OUTCOME MEASURES: Clinical and radiological outcomes were evaluated to assess mortality, morbidity, and surgical outcomes. A special interest was directed toward morbidity related to spinal deformity and neurologic deficits.

METHODS: Patients were divided into four groups: intramedullary (46 patients), intradural extramedullary (25 patients), extradural (53 patients), and paravertebral tumors (10 patients). Data were obtained retrospectively from medical records and radiological archives.

RESULTS: Low-grade glioma was the most common histology (14.1%). One hundred seventeen patients were surgically treated, with a total of 138 surgical procedures. A posterior approach was chosen in 111 cases, with osteoplastic laminotomy in 80. Radiotherapy was administered to 22 patients and chemotherapy to 26. At the last follow-up, 16 patients (11.9%) had died. A good control of the tumor with clinical improvement was reported in 100 patients (74.6%). Five patients developed a spinal instability (3.7%).

CONCLUSIONS: The goals of surgery should be histology, spine and nerve root decompression, and preservation of spinal stability. In our experience, osteoplastic laminotomy was a good surgical approach to perform the resection of the tumor with a low risk of secondary spinal instability.

Keywords: Spinal tumor; Children; Osteoplastic laminotomy; Laminectomy; Spinal deformity; Spinal instability

Introduction

Spinal tumors in children are a rare but complex pathology because of the heterogeneity in presentation, histology, evolution, and treatment. In many cases, diagnosis can be delayed because of a lack of specificity in clinical presentation. Tumors can arise from the nervous tissue, meningeal layers, bone, and paravertebral region. Treatment must

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* Corresponding author. Department of Neuroscience, Unit of Pediatric Neurosurgery, "Anna Meyer" Children's Hospital, Viale Pieraccini, 24, 50139 Florence, Italy. Tel.: (39) 055 566 2934; fax: (39) 055 566 2396.

E-mail address: lorenzo.genitori@meyer.it (L. Genitori)

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EVIDENCE & METHODS

Context
Due to their rarity, little is known regarding the ideal means of treatment and outcome of pediatric spinal tumors. In this context, the authors present their experience with 134 patients treated over a 16-year period.

Contribution
Low grade glioma was the most frequent diagnosis. Good tumor control and clinical improvement were reported in the vast majority of cases. Approximately 12% of patients died over the course of their care.

Implications
This large series of patients with pediatric spinal tumors treated over more than a 15-year period may provide useful information that can inform patient education and preoperative decision-making. As a retrospective, Level IV study, the findings presented here must be accepted in light of the potential for confounding by indication and selection among other potential biases. These factors may influence the capacity for replication in other clinical settings and in different pediatric patients with disparate types of spinal tumors. The number of patients in this study as well as the description of a single center experience likely represent the most valuable contributions from this work.

—The Editors

consider the natural history of the tumor, but when it comes to defining the treatment plan, it is important to evaluate the requirements of a growing spine.

We present our experience on spinal tumors in children based on a series of 134 patients treated between 1995 and 2011 in a single pediatric neurosurgery unit. Our aim is to highlight the pitfalls and complications of these multifaceted pathologies.

Materials and methods

Between 1995 and 2011, a total of 134 patients (75 males and 59 females [male-to-female ratio, 1.3:1]) were admitted for spinal tumors to a single unit of pediatric neurosurgery. They accounted for 7.7% of the patients admitted over the same time for central nervous system (CNS) malignancies. Case notes were retrospectively reviewed. The study obtained ethics approval by the hospital's Pediatric Ethics Committee.

Age

The mean age was 8.5 years (14 days–26 years). An analysis of the distribution of the patients according to age resulted in two main groups: the first, between birth and 36 months of age, with 31 patients (23.1%); and the second, between 10 and 15 years of age, with 46 patients (34.3%; Fig. 1).

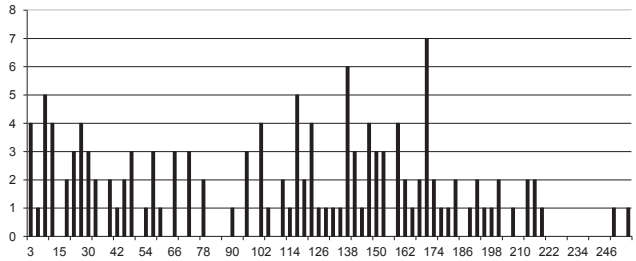

Fig. 1. Distribution of patients according to age in months at diagnosis. X, time in months; Y, number of patients.

Clinical presentation

Presenting signs and symptoms were varied and nonspecific. The most common were pain (54 patients [40.3%]), palpable mass (17 patients [12.7%]), and focal neurology (30 patients [22.5%]). The latter consisted of paraparesis (16 patients), monoparesis (11 patients), sphincteric problems (6 patients), hemiparesis (1 patient), sensory problems (1 patient), and ataxia (1 patient). Six patients (4.5%) were investigated for spinal deformity; scoliosis was found in four cases and kyphosis in two cases.

Eleven patients (8.1%) were completely asymptomatic. In this group, diagnosis was obtained during neuroradiologic follow-up for primary brain tumors (eight patients) or incidentally after a spinal injury (three patients).

Besides those patients, 16 more (11.9%) complained of vague symptoms such as headache, weight loss, vomiting, dyspnea, and torticollis. Among this group and those presenting only with pain, 25 were first offered an alternative treatment: 8 were evaluated by a psychologist, 4 were treated for gastrointestinal disorder and 4 for kidney disease, 3 were prescribed a collar, 2 were started on antibiotics, 2 underwent acupuncture and 1 physiotherapy, and 1 was investigated by a rheumatologist. Almost all the patients with pain were treated with nonsteroidal anti-inflammatory drugs and properly evaluated by a neurologist or a neurosurgeon only when the pain became unbearable and unresponsive to medical therapy or after the onset of neurologic focality. This resulted in a mean delay between the onset of symptoms/signs and the diagnosis of spinal tumor of 5.3 months (1 day–24 months).

When we compared the clinical evaluation at diagnosis with the first clinical presentation, it appeared that there was a noticeable increase in the number of patients with pain (65 vs. 54) and, even more importantly, an increase of patients with neurologic impairment: 46 had loss of power (paraparesis 29, monoparesis 11, hemiparesis 6), 18 had sphincteric problems, 14 had spinal deformity, and 16 had sensory dysfunction (14 anesthesia/hypoesthesia and 2 paresthesia; Fig. 2).

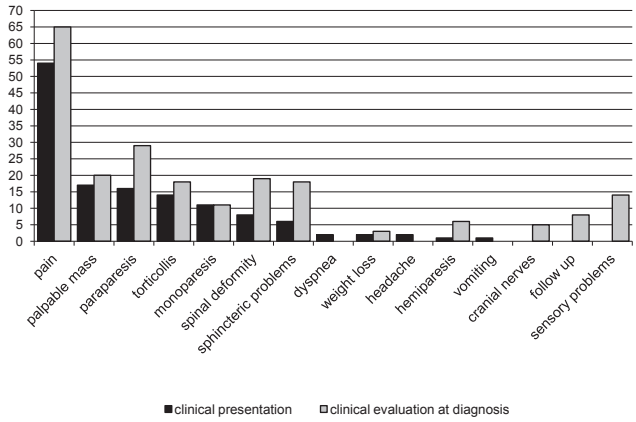

Fig. 2. A comparison between clinical presentation and clinical evaluation at diagnosis. X, clinical signs and symptoms; Y, number of patients.

Sixteen patients (11.9%) had a documented genetic disease. Neurofibromatosis Type 1 was diagnosed in 13 patients, neurofibromatosis Type 2 in 1, von Hippel-Lindau in 1, and adrenoleucodistrofia in 1.

Types of tumors

Patients were divided into four groups according to the relationship of the tumor with the spinal cord, the meninges, and the spine. Intramedullary tumors were diagnosed in 46 patients (34.3%), 25 (18.7%) had an intradural extramedullary tumor, extradural tumors were present in 53 cases (39.5%) with vertebral involvement in 32 and without vertebral involvement in 21, and 10 (7.5%) were classified as paravertebral tumors (Fig. 3).

In terms of localization along the spine, tumors located at the cervical and dorsal levels were the most common (93 patients, 69.4%), with a distribution as follows: 37 (27.6%) at the cervical level, 38 (28.4%) at the thoracic level, and 18 (13.4%) with involvement of both the cervical and thoracic spine. The remaining 41 (30.6%) involved the lumbar spine with or without extension to the thoracic or sacrococcygeal spine (Fig. 4).

Treatment

All patients were evaluated for surgical treatment in order at least to obtain the histology of the tumor. Seventeen patients were not operated on because of their general medical conditions (one patient), because the presence of a primary brain tumor was already known (eight patients), or because they were known to be affected by neurofibromatosis and were asymptomatic (seven patients); in one case with multiple diseases, a mastoid biopsy was preferred. These patients were discussed at the neuro-oncology multidisciplinary meeting and possibly directly started on medical therapy (chemotherapy and/or radiotherapy).

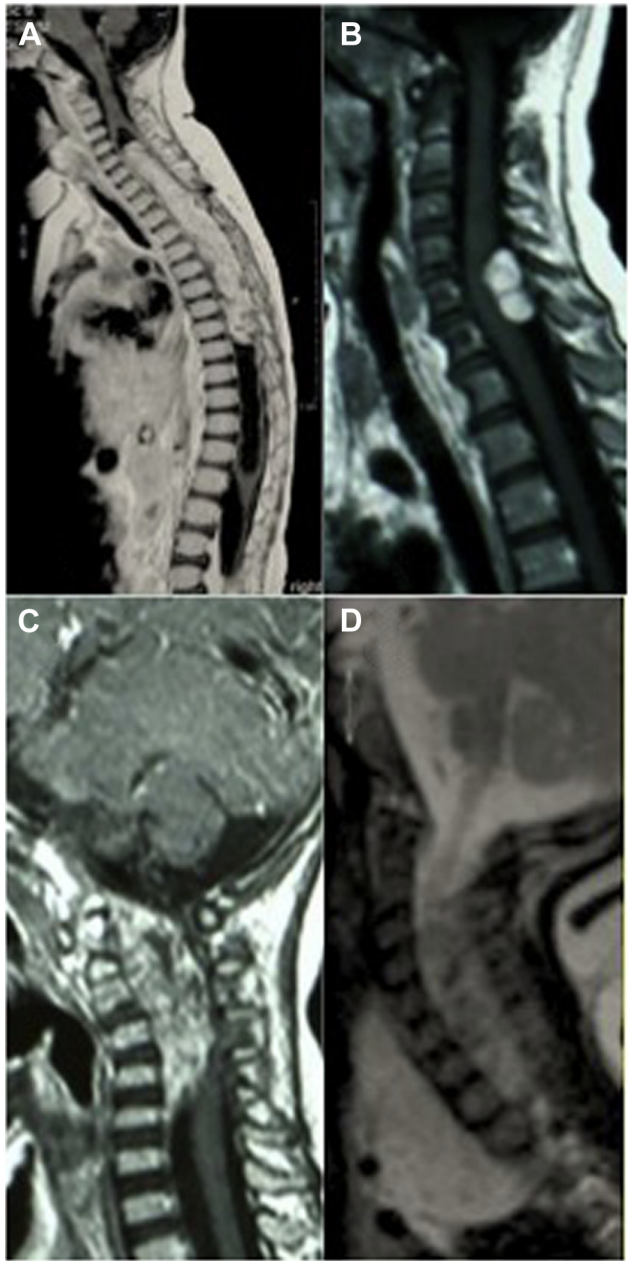

Fig. 3. Type of tumors divided according to their relationship with the spinal cord, the meninges, and the bone: (A) intramedullary tumor; (B) intradural extramedullary tumor; (C) extradural tumor; and (D) paravertebral tumor.

Surgical treatment

The Mayfield head clamp (Integra, Vista, CA, USA) was used only with children older than 3 years harboring a cervical or a cervicothoracic tumor. When dealing with children younger than 3 years, a horseshoe head holder was preferred.

Osteoplastic laminotomy, first described by Raimondi et al. in 1976 [1], was our favorite surgical strategy for posterior approaches and was performed in 80 cases. Through a midline incision, the bone was exposed and

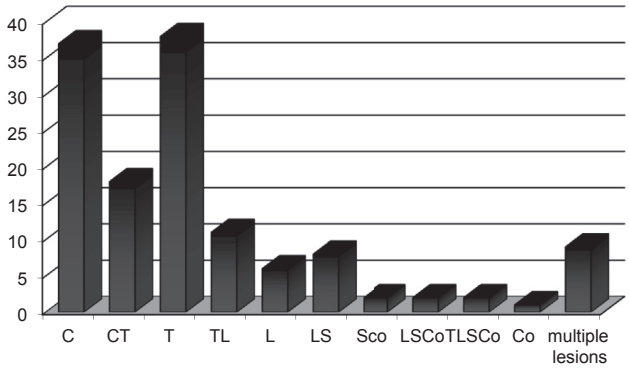

Fig. 4. Distribution of the tumors according to anatomic location. C, cervical; CT, cervicothoracic; T, thoracic; TL, thoracolumbar; L, lumbar; LS, lumbosacral; Sco, sacrococcygeal; LSCo, lumbar sacrococcygeal; TLSCo, thoracolumbar sacral coccygeal; Co, coccygeal; X, anatomical level occupied in the spine by the lesion; Y, number of lesions.

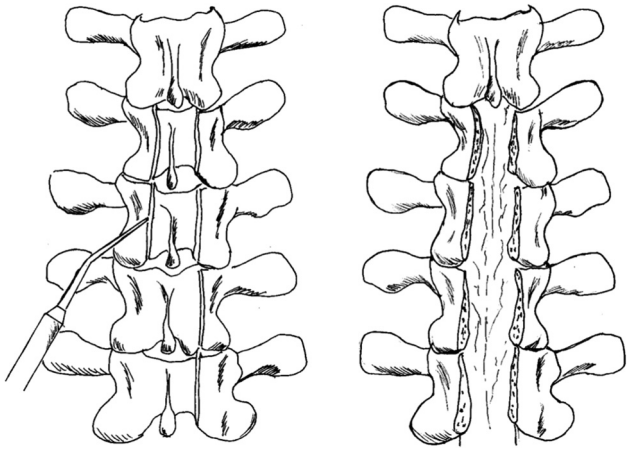

Fig. 6. Schematic drawing of the osteoplastic laminotomy. (Left) Spine during the cutting of the bone and (Right) dural sac seen through the window obtained after the laminae are reversed.

the laminae were cut with scissors in very young children, whereas in older children, we used a high-speed drill or a piezoelectric scalpel (Mectron Piezosurgery Medical System, Mectron s.p.a.; Carasco, Italy). The number of levels involved included one or two levels above and below the upper and lower ends of the tumor according to imaging. The osteotomy was performed at each side keeping an angle of approximately 30° from the outside to the inside of the spinal canal. Particular care was taken to preserve the lateral masses to reduce the risks of postoperative spinal deformity (Figs. 5 and 6, Left). The interspinous ligament, the posterior ligament, and the ligamentum flavum were divided at one end only, and the bone was then reversed (Figs. 6, Right, and 7). At the end of the procedure, the laminae were put back in their original position and reattached with stitches (Vicryl NR; Ethicon, Somerville, NJ, USA) passed between the two extremities of the previously cut ligaments. In very young children, stitches could go through the spinous processes. Small titanium plates were used in older children. Paravertebral muscles were sutured allowing the stitches at deeper layers to go through the interspinous ligament.

In the remaining 37 cases, the surgical approaches were performed through a laminectomy (31 cases) or through an anterior transthoracic or retroperitoneal approach (5 cases). In one case, diagnosis was obtained with a computed tomography–guided biopsy. Thirteen cases required a two-step surgery, with a posterior and an anterior approach in one case. Laminectomy was chosen when the tumor had already destroyed the bone (ie, aneurysmal bone cyst) or when the number of levels involved was limited, especially at the thoracic level.

Once the bone opening was completed, the surgery was performed under microscopy. For intradural tumors, masses with a clear plane between the tumor and the normal surrounding tissue (ie, cavernomas) were carefully dissected and removed. In the case of infiltrating tumor, the mass was reduced in volume from the inside as much as possible. Removal was performed with forceps and a Cavitron Ultrasonic Surgical Aspirator (CUSA; Integra, Vista, CA, USA).

With the aim of reducing the risk of cerebrospinal fluid (CSF) leak after surgery, patients operated for intradural lesions were kept in the Trendelenburg position for 3 days, then flat for 2 days, and were then allowed to stand up.

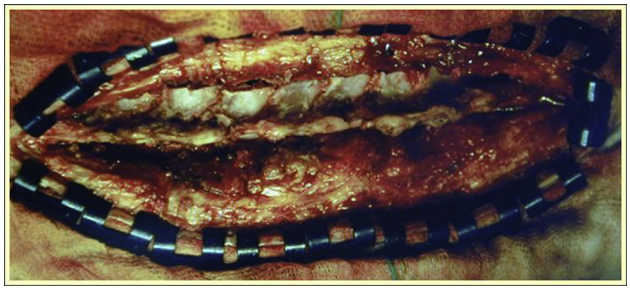

Fig. 5. Intraoperative picture from an osteoplastic laminotomy. A multilevel osteoplastic laminotomy is obtained by cutting the laminae on both sides following a 30° plane. The cut was obtained with a piezoelectric instrument.

Fig. 7. Intraoperative picture. After cutting the bone, the vertebrae are flipped, keeping the longitudinal ligaments intact on one side.

In any case, patients were allowed to stand up after surgery only when wearing a custom-made orthosis.

Imaging (magnetic resonance and/or computed tomography and/or X-ray) was obtained within the third postoperative day to assess the extent of the resection and the alignment of the spine.

Further treatment (chemotherapy and/or radiotherapy) was administered when the tumor resulted in a high-grade glioma, ependymoma, lymphoma, sarcoma, atypical teratoid rhabdoid tumor, neuroblastoma, or metastatic medulloblastoma (19 patients). Low-grade gliomas received further medical treatment only on recurrence (seven patients).

Complications

Complications related to the surgical procedure were experienced by 23 patients of the 117 operated (19.6%): 16 received a conservative treatment, whereas 7 required further surgical treatment. Four developed a CSF leak that was treated conservatively, keeping the patient in the Trendelenburg position; two patients had a wound infection treated with antibiotics. Eight patients experienced spinal cord shock, and two patients experienced nerve root damage. Spinal cord shock presented with paraparesis, clonus, loss of sphincter function, and priapism and resolved completely within 3 months after surgery in all but one patient, who had a residual spasticity of the lower limbs. A pump for intrathecal baclofen infusion was implanted with good improvement in terms of ability to walk unassisted.

Technical failure in the osteoplastic laminotomy leading to spinal instability and followed by a spinal deformity occurred in three cases. Two more patients operated with a different approach developed spinal instability.

One patient developed hydrocephalus that required a CSF shunting procedure. One patient developed a sudden neurologic deterioration with paraplegia on Day 3 after surgery because of intradural bleeding. The hematoma was evacuated, and the patient recovered completely.

Histology

Twenty-nine different histologic presentations were found. Tumors were considered malignant in 72 cases (53.7%). The most common were low-grade glioma (19 patients), neuroblastoma (12 patients), neurofibroma (11 patients), neurinoma (11 patients), sarcoma (9 patients), cavernoma and vascular malformation (9 patients), ependymoma (9 patients), high-grade glioma (6 patients), and lymphoma (4 patients).

One patient with a low-grade glioma had a recurrence 12 months after surgery; at that time, the tumor had undergone a malignant transformation to a high-grade glioma although the patient had not received chemotherapy or radiotherapy after the initial diagnosis (Fig. 8).

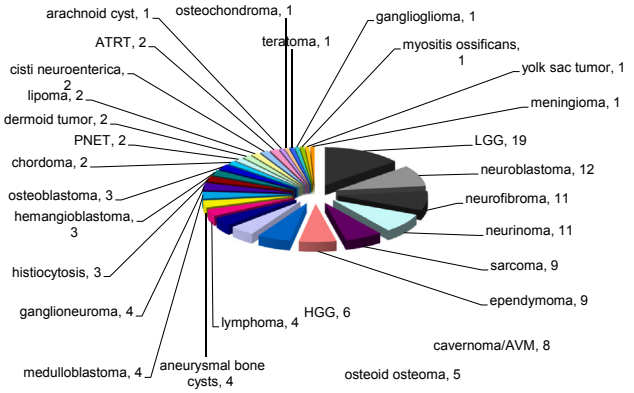

Fig. 8. Distribution according to the histology. ATRT, atypical teratoid rhabdoid tumor; LGG, low-grade glioma; HGG, high-grade glioma; AVM, artero venous malformation; PNET, primitive neuroectodermal tumor.

Results

All patients were assessed in the clinic at 1, 3, 6, and 12 months after surgery and yearly thereafter. After every consultation, patients were discussed at the multidisciplinary neuro-oncology meeting. Patients started on chemotherapy and/or radiotherapy were followed up by the oncologist. The mean follow-up was 28 months (3 months–13 years).

A spinal X-ray was obtained at 1, 3, and 6 months after surgery to evaluate the healing of the osteoplastic laminotomy and the stability of the spine. We considered X-rays that were unchanged or improved when compared with the preoperative and immediately postoperative scans to be satisfactory. In those cases, we did not calculate specific parameters in terms of angles of the spine, and the orthosis was removed at 3-month follow-up whenever the scans and the general and neurologic conditions of the patients were judged satisfactory. Patients presenting with a worsening of the already-known deformity or with a new one were asked to keep the orthosis 3 months longer.

During follow-up, five patients (3.7%) developed a spinal instability that required a surgical treatment. In three cases, the deformity was judged to be the result of a technical failure of the osteoplastic laminotomy: in one, an inadequate angle of the cut of the laminae did not allow an appropriate plane to replace them, and the posterior arches dislocated within the spinal canal; in two, the laminotomy extended too far and involved the lateral masses. Two of those patients already had a spinal deformity at diagnosis that worsened after surgery. The tumor was located at the cervical level in three patients, at the cervicothoracic level in one patient, and at the thoracic level in one patient. Four patients developed a kyphosis, whereas the patient with a tumor at the thoracic level developed a scoliosis. Four were operated on (one with an anterior approach, two with a posterior approach, and one with a combined anterior and posterior approach). One patient was not operated on because of a poor general condition.

Eleven patients were found to have a spinal deformity at the 3-month assessment that was not deemed to require further surgery but rather conservative management with orthosis and reassessment at 3 months. The same management was reserved for four patients who developed a worsening of a spinal deformity that had already been present at diagnosis but were still not considered to be suitable for surgery. At the 6-month follow-up, none of them showed any further radiologic or neurologic worsening, and the orthosis was removed. No progression was revealed at the X-ray scan 3 months later (9 months after surgery).

Magnetic resonance imaging scans were performed before any scheduled consultation unless the patient was enrolled in oncology protocols for chemotherapy and/or radiotherapy. The disease recurred in 12 cases; 7 were intramedullary tumors. They all received further surgery. One patient with a low-grade glioma treated only with surgery had a malignant transformation to a high-grade glioma at recurrence. Further medical treatment was administered for recurrent tumors according to their histology. At last follow-up (mean 28 months, minimum 3 months, maximum 13 years), 8 patients (5.9%) had neurologically worsened, 10 (7.4%) were unchanged, and 100 (74.6%) had improved or had a normal neurologic examination. Death related to disease progression was recorded in 16 patients (11.9%), 8 of whom had intramedullary tumors, 4 of whom had an intradural extramedullary tumor, and 4 of whom had an extradural tumor. The mean age at diagnosis for this group of patients was 5.8 years (1 month–12 years).

Discussion

Spinal tumors in children are difficult to manage because of their clinical presentation, extreme variability of histology, and low incidence. They account for a small proportion of CNS tumors in children, with an overall incidence rate between 1 and 2.7 cases per 1 million children [2–4]. As a consequence, there is a paucity of large series published.

Our series consists of 134 patients treated by the senior author (L.G.) between 1995 and 2011 and accounts for 7.7% of all the CNS tumors observed by the team over the same time. The mean age was 8.5 years (14 days–26 years), with a higher incidence during the first 3 years of life (23.1%) and between 10 and 15 years of life (34.3%).

The results of our study confirm epidemiologic data from the literature. Their incidence is estimated to account for 5% to 20% of CNS tumors in children [2,5,6]. Frequently, pediatric patients have lesions involving multiple levels. Intramedullary tumors in younger children can involve more than six levels [7]. In our study, 70 patients had at least three levels involved (52.2%). Wetjen and Raffel [6] evaluated the distribution of spinal tumors according to their anatomic location calculated in 10 studies and reported as follows: intramedullary tumors 29.7%, intradural extramedullary tumors 24.6%, extradural 34.5%, and other locations 11.2%. In our study, the tumor was intramedullary in 46 patients (34.3%), intradural extramedullary in 25 (18.7%), extradural in 53 (39.5%), and paravertebral in 10 (7.5%).

One issue that emerges from our study is the delay between the first clinical presentation of the tumor and diagnosis. This finding is well reported in the literature [2,8]. In our study, the mean delay was 5.3 months (minimum 1 day–maximum 2 years). Seventy patients (52.2%) presented with vague symptoms and back pain and were not investigated for spinal problems until they developed new signs or symptoms. This is not enough to develop guidelines, but it is probably of note that back pain in an otherwise healthy child with no history of injury is quite unusual and should be cause for attention.

Our study supports the idea that osteoplastic laminotomy, even if multiple levels are involved, followed by the use of a custom-made orthosis for at least 3 months after surgery is associated with a low risk of spinal instability. In some studies, this risk after laminectomy is as high as 100% when dealing with cervical tumors [9–11], whereas it is lower after laminotomy [1,12,13]. The reasons are probably related to multiple factors. Constantini et al. [14] found a risk of spinal deformity of 31% after laminotomy for spinal tumor, although they did not report any acute complications in more than 300 laminotomies performed for rhizotomies. On the other hand, Ratliff and Cooper [15] concluded that there is no benefit to laminotomy over laminectomy at the cervical level in adult patients. The higher risk of instability after surgery for tumors might depend on not only the surgery itself but also the adjuvant therapy and the neurogenic effect of intramedullary spinal tumors [14]. The laxity of the ligaments, the cartilage content in the immature spine, and the vectors of spine growth, even oriented by the adjacent segments, probably make the pediatric spine more likely to develop a deformity after a laminectomy [11,16–18] than after a laminotomy [19]. In our study, a spinal instability requiring further surgery occurred in five patients (3.7%): three were a technical failure of the laminotomy, whereas two were originally operated with a laminectomy. The tumor was located at the cervical level in three, at the cervicothoracic level in one, and at the thoracic level in one. Four developed a kyphosis, whereas the patient with the thoracic tumor developed a scoliosis. The relatively low risk of spinal deformity in our study may be related to the use of osteoplastic laminotomy (80 patients) and the use of a custom-made orthosis for at least 3 months after surgery, which in any case is probably useful for the correct healing of the bone after surgery.

It is interesting to observe that acutely after surgery for intramedullary and intradural extramedullary tumor, 57 patients (80% of the patients with these tumors) developed a transient neurologic deterioration with a medullary shock in 8 patients. All but one, who required the implant of a pump for intrathecal baclofen infusion for spasticity,

recovered completely to the preoperative status. This temporary neurologic deterioration is reported by various authors [20,21], but the risk of permanent neurologic worsening appears to be related to the preoperative neurologic status [7,8,14,22].

Our series was very heterogeneous in terms of histology. This heterogeneity, well reported in the literature [7], is the cause of the difficulty in defining specific treatment protocols. Our data confirm that a younger age at diagnosis is associated with a higher risk of aggressive histology [23] and that high-grade intramedullary tumors are associated with a worse prognosis [7,8,14,22]. The mean age at diagnosis for patients who died was lower than the overall mean age at diagnosis (5.8 years vs. 8.5 years); 8 of 16 patients who had died at last follow-up had a high-grade intramedullary tumor. One case of low-grade glioma, treated only with surgery, that evolved to a high-grade glioma is of note. Similar cases of spontaneous malignant transformation have occasionally been reported [24].

Conclusions

This study suffers from the limits of a retrospective study but evidences at least two points that may contribute to a better outcome in children with spinal tumors: back pain in children should not be underestimated and osteoplastic laminotomy followed by a custom-made orthosis appears to reduce the risk of spinal instability.

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